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Title: Non-Invasive Acoustic-Based Monitoring of Heavy Water

Author(s): Pantea, Cristian
Sinha, Dipen N.
Lakis, Rollin Evan
Beedle, Christopher Craig
Davis, Eric Sean

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Acoustic Interrogation in Safeguards

Non-Invasive Acoustic-Based Monitoring of Heavy Water

Cristian Pantea, Dipen Sinha, Rollin Lakis,
Chris Beedle, Eric Davis

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Heavy Water Production Monitoring: A Recent Challenge for the IAEA

Arak Heavy Water Production Facility
Girdler sulfide process + distillation

JCPOA-130 metric ton limit

Non-invasive acoustic-based monitoring of Hydrogen/Deuterium ratio

- Context: There is a need for real-time process monitoring and person-portable in-field tools for the determination of the hydrogen /deuterium ratio (H/D) in heavy water production facilities.
- Current methods for H/D determination require periodic sampling and analysis. This approach does not provide the opportunity for continuous monitoring and verification by the IAEA and is relatively expensive, error prone and inefficient.
- Acoustic methods provide the opportunity to measure H/D for near real time process monitoring, noninvasive (dry) in situ inventory verification measurements (kegs) and rapid, reliable onsite wet measurements.
- Acoustic methods leverage the fact that sound speed is sensitive to the deuterium content of heavy water and can be measured using well established theory and commercial components.

Project Goal

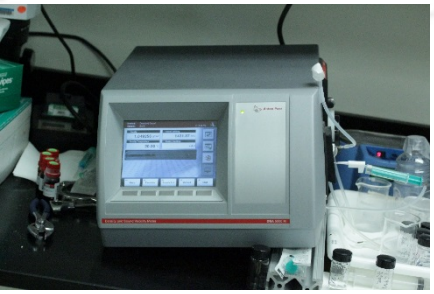
- Develop a new verification capability that is
  - Nondestructive
  - Nonintrusive
  - Easy to deploy
  - Reliable and accurate

Non-invasive acoustic-based monitoring of Hydrogen/Deuterium ratio

- We propose an approach that can lead to a precision and accuracy of better than ± 0.2%, volumetric.
- A quick literature search leads to precisions of ± 0.2-0.4% using other methods, gravimetric, float bath, displacement, mass spectrometry, IR Spectroscopy, emission spectroscopy, nuclear magnetic resonance, cryoscopy, refractometry, etc.)
- All these require drawing of a sample, elaborate sample preparation, time consuming, depends on user interpretation.
- Our approach consists of a clamp-on type device/sampling cell that can accurately measure D_2O concentration in real-time in real settings.

Noninvasive Measurements in SFAI Cell

Lab environment



Anton-Paar

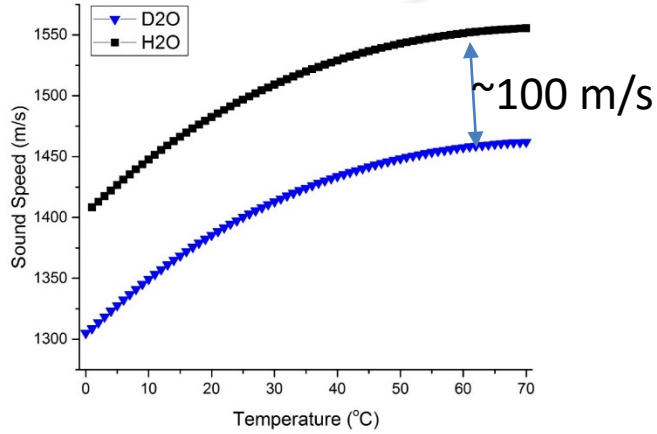
Lab SFAI cell

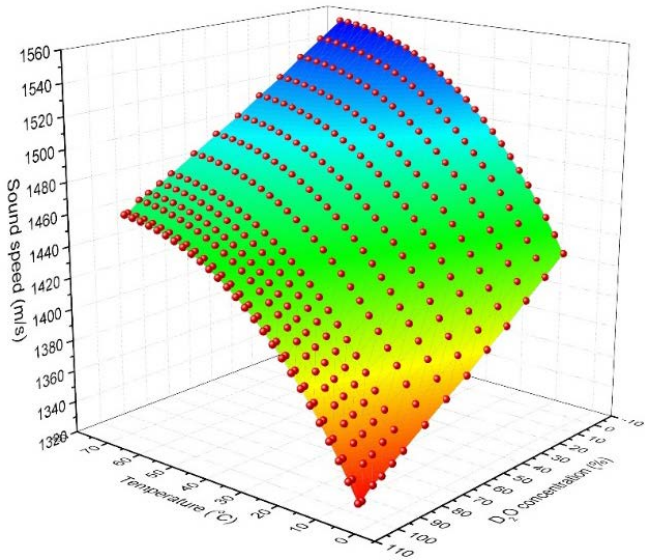
Field

SFAI: Swept-Frequency Acoustic Interferometry

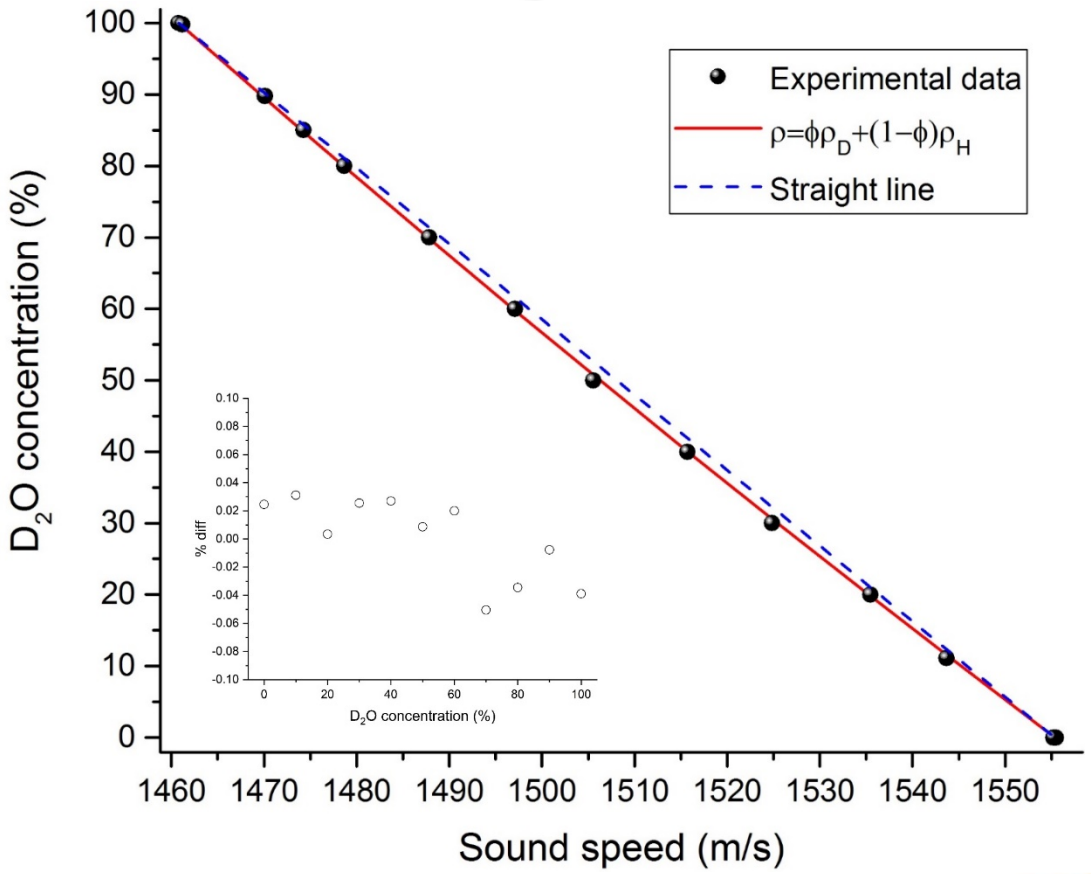
- was developed 20+ years ago in our lab

Highest Precision Sound Speed Data Available: New Standard in H/D





→ high precision/accuracy for D_2O concentration, ~ 0.1%



*precisions of ± 0.2-0.4% using other methods, gravimetric, float bath, displacement, mass spectrometry, IR Spectroscopy, emission spectroscopy, nuclear magnetic resonance, cryoscopy, refractometry, etc.)

Timeline

- **Task 1 Portable on-site inspection tool development – CONOPS 1 (FY18-FY19)**

  Deliverable 1: *Portable tool functionality demonstrated in the laboratory (end of FY18).*

- **Task 2 User-friendly software interface development (FY18-FY19)**

- **Task 3 Continuous unattended monitoring development – CONOPS 2 (FY19)**

  Deliverable 2: *Continuous unattended tool functionality demonstrated in the lab (end FY19).*

- **Task 4 Field tests and technique refinement (FY20)**

  Test/demonstrate developed system in an actual environment.

  Deliverable 3: *Demonstration of system in field functionality similar to the one observed in tests in the laboratory.*

Status

- **Task 1** *on track – sampling cell functionality demonstrated; need temperature controller – working on clamp-on tool*
- **Task 2** *on track – working on data acquisition interface*
- **Task 3** *work will start in FY19*
- **Task 4** *work will start in FY20*

*Sampling cell field testing prototype available in 3-9 months

Summary

- Developed methodology for in-situ and onsite verification of D_2O inventory
- Simple, low cost, modest electronics, easy deployable